AD NUMBER

ADB220453

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; Jan 97. Other requests shall be referred to Army Aeromedical Research Lab., Fort Rucker, AL 36362-0577.

AUTHORITY

USAARL ltr, 18 Mar 2003

USAARL Report No. 97-09

Operational Test to Evaluate the Effectiveness of the Communication Earplug and Active Noise Reduction Devices When Used with the HGU-56P Aviator Helmet

By

Robert N. Staton
Ben T. Mozo
Barbara A. Murphy

Aircrew Protection Division

January 1997

U.S. Army Aeromedical Research Laboratory
Fort Rucker, Alabama 36362-0577

Notice

Qualified requesters

Qualified requesters may obtain copies from the Defense Technical Information Center (DTIC), Cameron Station, Alexandria, Virginia 22314. Orders will be expedited if placed through the librarian or other person designated to request documents from DTIC.

Change of address

Organizations receiving reports from the U.S. Army Aeromedical Research Laboratory on automatic mailing lists should confirm correct address when corresponding about laboratory reports.

Disposition

Destroy this document when it is no longer needed. Do not return it to the originator.

Disclaimer

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation. Citation of trade names in this report does not constitute an official Department of the Army endorsement or approval of the use of such commercial items.

Human use

Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRMC Reg 70-25 on Use of Volunteers in Research.

Reviewed:

JOHN P. ALBANO
MAJ, MC, SFS
Director, Aircrew Protection
Division

Released for publication:

JOHN A. CALDWELL, Ph.D.
Chairman, Scientific
Review Committee

DENNIS F. SHANAHAN
Colonel, MC, MFS
Commanding

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION
Unclassified

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE

3. DISTRIBUTION / AVAILABILITY OF REPORT
Distribution authorized to U.S. Government agencies only, Test and Evaluation, January 1997. Other requests to,

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
USAARL Report No. 97-09

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
U.S. Army Aeromedical Research Laboratory

6b. OFFICE SYMBOL (If applicable)
MCMR-UAD

7a. NAME OF MONITORING ORGANIZATION
U.S. Army Medical Research and Materiel Command

6c. ADDRESS (City, State, and ZIP Code)
P.O. Box 620577
Fort Rucker, AL 36362-0577

7b. ADDRESS (City, State, and ZIP Code)
Fort Detrick
Frederick, MD 21702-5012

8a. NAME OF FUNDING / SPONSORING ORGANIZATION

8b. OFFICE SYMBOL (If applicable)

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
63787A	3016287A878	OF	DA360347

11. TITLE (Include Security Classification)
Operational test to evaluate the effectiveness of the communication earplug and selected active noise reduction devices when used with the HGU-56/P aviation helmet (U)

12. PERSONAL AUTHOR(S)
Robert N. Staton, Ben T. Mozo and Barbara A. Murphy

13a. TYPE OF REPORT	13b. TIME COVERED FROM TO	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final		1997 January	28

16. SUPPLEMENTAL NOTATION

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Communications Earplug, CEP, active noise reduction, ANR, HGU-56/P, sound attenuation, speech intelligibility, chemical/biological, CB, ANVIS

19. ABSTRACT (Continue on reverse if necessary and identify by block number)
Thirty-nine aviators/crewmembers assigned to FLATIRON, U.S. Army Aeromedical Center, 1/14th Aviation Regiment, Fort Rucker, Alabama, and SOATC,160th SOAR(A), Fort Campbell, Kentucky, participated in an operational evaluation of the HGU-56/P aviation helmet equipped with three different active noise reduction (ANR) systems and the communication earplug (CEP) in routine daily aviation mission environments. Results of weekly and posttrial comprehensive surveys are discussed. The operational assessment found that both CEP and ANR systems reduce noise exposure levels at the wearer's ear and improve speech intelligibility (SI) characteristics of the HGU-56/P helmet system. Intercommunication system volume controls are reduced significantly from levels normally used with the standard helmet. Effects on sound attenuation and SI when wearing spectacles with ANR and standard helmet are minimal. The chemical biological mask wearing causes significant reduction in helmet system performance for standard and ANR configurations with earseal compromise. No effect was observed for the combination protection or the CEP. ANR systems do not show any positive effect in reducing impulse noise levels from weapon
(Continued on next page)

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
Chief, Science Support Center	(334) 255-6907	MCMR-UAX-SI

DD Form 1473, JUN 86 *Previous editions are obsolete.*

SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

19. Abstract (Continued):

muzzles encountered in Army aviation noise environments. A system fielding decision will require noting effects of helmet weight, ancillary devices, safety, performance, user acceptance and cost. Subject preference choice was the CEP.

Acknowledgments

The authors wish to recognize the invaluable assistance of Mr. Tom Frezell, Human Factors Branch, Essex Corporation, for a critique of the weekly and comprehensive questionnaires. We are also most grateful to the test subjects for their voluntary cooperation and participation.

Table of contents

List of tables

Tables

Introduction

Operational noise levels in U.S. Army helicopters exceed safe limits when assessed in accordance with limits set in DOD Instruction 6055.12. In certain cases, the ability to protect hearing of the aviator and crewmember with the helmet worn alone is marginal. The use of combination protection (i.e., the wearing of earplugs) extends the problem in cases where intercommunication systems are not capable of producing speech levels needed to overcome earplug sound attenuation. Voice communications are of critical importance to the aviation mission (Camp, Mozo, and Patterson, 1975). Rapid and complete comprehension of message contents are required in order to maintain operational advantage over opposition forces. To solve this problem, the Army is evaluating hearing protection/communication devices integrated with the new issue HGU-56/P aviation helmet that improves speech intelligibility in noise.

Background

The U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, Alabama; Program Manager-Aircrew Integrated Systems (PM ACIS), St. Louis, Missouri; and three corporations entered into a cooperative research and development agreement (CRDA) to explore the capabilities of active noise reduction (ANR) for potential use in Army aviation. The manufacturers agreed to modify HGU-56/P aviation helmets by installing their respective ANR systems. USAARL agreed to evaluate the modified helmets in their laboratory and in the operational environment. The helmet mounted communications earplug (CEP) also was included in the evaluation procedure. The respective manufacturers: Grumman Aerospace*, Bose*, and Gentex* Corporations provided three sizes of ANR modified helmets for evaluation. Three sizes of helmets were modified with the CEP by USAARL personnel. The candidate devices were compared to the standard HGU-56/P aviation helmet. USAARL conducted a laboratory evaluation of speech intelligibility and attenuation of the five helmets/devices under controlled conditions on 18 normal hearing aviator subjects (ANSI Standard 12.6, 1984; MIL-STD-912, 1990; Mozo and Murphy, 1996).

Two separate systems were utilized in the HGU-56/P aviation helmet operational assessment to reduce noise exposure and improve voice communications (Mason and Mozo, 1995). One technique, ANR, uses electronic circuitry to manipulate and reduce the noise found inside the earcup. This is made possible by reinserting a processed and out-of-phase noise signal back into the earcup through an earphone. The reinserted sound signal combines with the noise and causes it to be canceled. This out-of-phase canceling technique usually is very effective for low frequencies below 800 Hz, but generally is ineffective for higher frequencies. In some designs, the ANR device actually increases the noise level inside the earcup in the region where ANR

---

* See list of manufacturers.

crosses zero attenuation. Total protection provided by the ANR system consists of the passive hearing protection provided by the earcup, in addition to the ANR noise reduction provided by the electronic package.

The CEP is a device which incorporates a miniature earphone coupled with a replaceable foam earplug tip and can be worn in combination with the aviation helmet. The system consists of a miniature receiver encapsulated in a plastic housing which possesses a threaded adapter used for attaching the replaceable earplug. The speech signal is delivered directly from the receiver into the occluded portion of the ear canal. The small wire used to connect the CEP into the communications system is highly flexible for comfort and small enough to reduce the potential for leakage when the wire is routed between the earseal and the wearer's head.

Methods

The 39 subjects (38 male, 1 female) participating in this operational study were aviators and crewmembers from the following units: 1/14th Aviation Regiment [OH-58D(I)], [CH-47D(I)], Hanchey AHP; FLATIRON USAAMC (UH-1H Crash Rescue), Cairns AAF of Fort Rucker, Alabama; and the 160th SOAR(A), SOATC (MH-6C, MH-60K and MH-47E), Fort Campbell, Kentucky. HGU-56/P aviation helmets utilizing selected ANR systems and CEP were fitted individually to each subject by an Aviation Life Support Equipment (ALSE) technician. The fit of the device was monitored by the onsite evaluator during training. Additional instruction was provided, as necessary. The Grumman Aerospace ANR system was withdrawn from the operational assessment for safety reasons. It failed to provide communication capability during loss of battery power and did not provide reliable intercommunication system contact between OH-58D crewmembers or incoming radio traffic.

The helmets/devices were worn by the subjects for a 1-week period for at least two flights and a total flight time minimum of 4 hours for each of the test items. Wearing conditions included the helmet alone, with spectacles/chemical biological (CB) mask, and aviator's night vision imaging system (ANVIS), if appropriate, during mission performance. Additionally, aviators and crewmembers were asked to wear insertable earplugs with ANR and HGU-56/P standard helmet conditions if live weapons fire practice was included in the daily mission. Individuals had the option to use insertable ear protection when wearing either the ANR or the standard HGU-56/P helmets. The 160th SOAR(A) SOATC had previously received the HGU-56/P as a standard issue; therefore, it was used as the helmet reference point.

Subjects were asked to respond to a 33-item questionnaire after each weekly helmet operational assessment and a 30-item comprehensive rank ordering survey at the completion of the study (appendices A and B). Responses to the weekly version were based on a seven-point rating scheme, to include a point of reference. A "1" response was considered best and "7" considered worst. The comprehensive questionnaire required a rank order assessment of the four helmet systems. Ample opportunities for written comments were afforded on both

questionnaires. Categories of evaluation included speech clarity/understanding, comfort, donning/doffing, noise reduction/attenuation, compatibility, and general issues. The presence of hearing loss and/or flight waiver status were recorded for each subject.

Results and discussion

Subjects ranged in rank from Specialist to Captain (9 crewmembers, 30 aviators). Three individuals were retired U.S. Army CW-4's. The overall mean age was 34.4 years (range 25-48), mean flying experience in years was 9.3 (range 0.75-28), and mean lifetime flight hours was 2,264.5 (range 150-9500). Unit specific results were as follows: 1/14 Aviation Regiment had an overall mean age of 36.1 years, mean flying experience of 10.1 years, and mean lifetime flight hours of 2,783.3. The 160th SOAR(A) SOATC had an overall mean age of 35.9 years, mean flying experience of 13.3 years, and mean lifetime flight hours of 2,804.5. FLATIRON had an overall mean age of 29.8 years, mean flying experience of 5.6 years, and mean lifetime flight hours of 1,125.4. Eleven respondents reported having hearing loss present at least monaurally. Two subjects possessed a hearing loss flight waiver.

Speech clarity/understanding

The CEP configuration was superior in terms of clarity of in-flight communication, greatest lowering of inner communication system (ICS)/radio volume and clarity of air traffic controller transmissions based on gender and facility with standard English. It was the clear overall choice, particularly in special operations applications. Subject comment areas merit the following discussion: Bose and Gentex produced inappropriate system unreliability with volume reductions in voice-activated and high frequency end of ICS systems. Gentex was of particular subject concern in this area. This caused difficulty in clarity/understanding of female voices. External power source variability on the ANR systems was a frequent complaint and it was a safety concern on night vision missions. Both Bose and Gentex helmets were considered unsatisfactory if CB mask wearing forced a break in the earcup seal. Additionally, the ANR systems were ineffective, or considered no better than the standard helmet during .50-caliber impulse noise-generated weapons fire during OH-58D missions. Finally, instances of ANR circuit instability or malfunction and unplanned power source failures compromised mission safety.

Table 1.
Subject clarity rating of helmet systems.

Device	In-flight commo clarity	Lower ICS/radio vol	ATC clarity gender	ATC clarity stnd English
HGU-56/P	3.6	3.3	3.6	3.7
Bose	1.9	1.9	1.9	1.9
Gentex	2.8	2.9	2.8	2.7
CEP	1.7	1.8	1.6	1.7

Comfort

All helmet systems were largely equal in terms of initial notice of discomfort, earseal fit, limitation of "hot spots, perspiration, and headaches, as well as overall comfort (Mozo, Murphy and Ribera, 1995). There was a general subject concern over the CEP wire comfort as to its exit placement on the transducer. This problem has been corrected largely by placement of the wire/transducer interface in a 90- degree "elbow" design. General consensus on the replaceable earplug tips was positive for texture, stiffness, and insertability. Bose's gel earseals generally received favorable comments. Negative responses were from subjects with large pinnas and situations requiring wear in high temperature and humidity environments. The helmet size differential between the HGU-56/P and SPH-4B caused greater difficulty for subjects not having the new model as an issue item. In particular, "hot spots" in the forehead area were more likely to occur in the HGU-56/P with ANVIS use. On the positive side, there was an almost universal subject request to have the aircraft configured to take advantage of the HGU-56/P air conditioning interface. Comfort was considered comparable for all helmet systems. The fact that 54 percent of participating aircrews normally wear earplugs in combination with the helmet most likely contributed to overall comfort equivalency.

Table 2.
Comfort ratings of helmet systems.

Device	Discomfort onset/time	Earseal fit	Limit hot spots, perspiration, and headaches	Overall comfort
HGU-56/P	1.4	2.9	2.4	2.3
Bose	1.5	1.9	2.1	2.1
Gentex	1.3	2.6	2.8	2.8
CEP	1.0	2.5	2.4	2.6

Donning/doffing

The standard HGU-56/P helmet was the easiest helmet to task in this category. The CEP was considered the most difficult because of additional steps. Subject concern was expressed that transducers would pull out when donning and doffing if helmet connection had not been broken. User experience tended to mitigate this problem over time. The nape strap adjustment on the HGU-56/P required a short time subject adjustment. There was strong preference for a "snap on" chinstrap on the newer model helmet despite safety design concerns for the present system.

Table 3.
Helmet system donning/doffing.

Device	Difficulty in donning/doffing
HGU-56/P	1.4
Bose	2.4
Gentex	2.5
CEP	3.2

Noise reduction/attenuation

The CEP was the system of choice in greatest reduction noise levels at the ear, providing best awareness of warning/navigation signals and monitoring of aircraft "environmental sounds." Additionally, the CEP was significantly superior with respect to communication, navigation, and

warning signal clarity during aircraft weapons firing. ANR systems do not show any positive effect in reducing impulse noise levels encountered in Army aviation noise environments. Because of the high potential hazard to hearing, insert protection in combination with the helmet has been recommended and, in some cases [i.e., 1/14th Aviation Regiment-OH-58D(I)] is unit standard operating procedure for training scenarios involving weapons fire from open cockpit aircraft. Several subjects were concerned over the apparent "wind tunnel" generated by the HGU-56/P helmet while flying with doors-off. In several cases, instability of the ANR circuitry was troublesome but it did not detract from successful mission completion. In cases of ANR malfunction, the helmet power source would be disconnected or the subjects would switch to their personal helmet.

Table 4.
Helmet system signal clarity rank ordering.

Device	Noise levels	Navigation/ warning	Weapons fire	Environment	Extra noise
HGU-56/P	3.6	3.6	3.4	2.4	2.8
Bose	1.9	1.9	2.6	2.3	2.1
Gentex	2.6	2.8	2.5	2.7	3.0
CEP	1.9	1.6	1.2	2.5	1.9

Compatibility

Helmet systems were considered equivalent in terms of interface with spectacles, CB mask, and ANVIS (note: not all subjects were able to evaluate each ancillary device condition). The standard helmet proved to be the most compatible with the CB mask, and the other three systems were roughly equivalent. However, wearing the CB mask causes significant reduction in the helmet system performance for standard and ANR configurations. Loss of adequate communication coupled with increased noise exposure and compromise of the visual system by CB mask use leaves the aviator/crewmember in an uncertain state. Factoring night vision goggles (NVGs) into the helmet system further complicates the situation. As mentioned previously, a significant number of subjects expressed preference for a "snap on" chinstrap. There was almost universal concern about battery packs on the ANR systems. The repeated failures were considered a mission "no go." Direct aircraft power would be required for ANR fielding. Repeated subject concerns were voiced over the CEP transducer's place of attachment and angle of extension. Also as mentioned previously, a redesign has solved this problem. The CEP attachment to the helmet will be a direct "plug in," solving an additional concern. A number of comments surfaced regarding ANVIS interface on the HGU-56/P. Initial use of the helmet caused a perceived visual

field restriction because of a greater distance of the earcup area from the temple region of the face. Human factors and USAARL's vision research proved this to be a visual illusion that soon disappears. Extended ANVIS use often caused "hot spot" generation in the forehead area. Finally, the ANVIS battery connection on the top of the helmet had a faulty design angle that caused eventual mount breakage.

Table 5.
Helmet ancillary device comparisons.

Device	Spectacles(N=9)	CB mask(N=8)	NVG(N=24)
HGU-56/P	2.3	1.1	2.1
Bose`	2.3	2.6	2.0
Gentex	3.0	3.0	2.5
CEP	2.0	2.6	2.0

General Issues

The CEP configuration was the system of choice in terms of operational benefit and selection as a preference item. The 160th SOAR(A) SOATC subject weekly questionnaire responses (appendix A) indicate that ANR systems, as presently configured for this study, may interject an additional safety risk factor in special operations live combat missions in daytime and under NVG conditions. Additionally, indications are that mission profiles, aircraft systems' sophistication, and length of flight experience have direct relationships as to the choice of voice communications and noise attenuation.

While user acceptance and cost are of secondary importance, they are also critical to the decision process. Safety principles must be considered for both auditory performance enhancements and mechanical factors designed to protect the aviator/crewmember during normal missions and events which are unexpected and/or unplanned (Mozo and Murphy, 1996). Side impacts in the helicopter environment have been shown to produce significant head injuries during crashes which, in many cases, are preventable with energy-absorbing earcups (Shanahan, 1985). The weight of the helmet is a significant factor for increased injury during a crash and adds to the burden supported by the individual during flight. Further, the flight helmet has become a platform for many weapons system devices which must be coupled to the aviator/ crewmember. Additional techniques to reduce that burden must be explored.

Table 6.
Helmet operational benefit preferences.

Device	Preference percentage
HGU-56/P	5
Bose	33
Gentex	5
CEP	57

Conclusions

Results of this study show that both the CEP and ANR systems reduce noise and improve speech intelligibility characteristics of the HGU-56/P helmet system. A previous USAARL study determining the effect of ANR and CEP on hearing-impaired aviators and crewmembers showed dramatic improvements (Ribera and Mozo, 1996). Individuals wearing the SPH-4B went from 1 percent to 40 percent SI with ANR, and to 65 percent SI when using the CEP system. Maximum levels of speech intelligibility were reached at much lower intensity levels, reducing the hazardous effects of the speech signal. The operational test yielded the following additional findings: ICS volume levels are reduced significantly from levels normally used for the standard helmet. Effects on sound attenuation and speech intelligibility when wearing spectacles with ANR and the standard helmet are minimal. No effect was observed for the combination protection provided by the CEP and yellow foam earplug (E-A-R). Impulse noise hazard becomes a significant issue when considering the large number of rounds being fired from open cockpit aircraft with weapon muzzles located near the crewmember's ear. Overall comfort was considered comparable for all helmet systems. Donning/doffing of the CEP was considered to be more difficult with an additional step in the process. Subjects did not feel any of the helmet systems reduced their awareness of operational noises needed to ensure proper operation of the helicopter. Aviator/crewmember preference for overall system characteristics show the CEP is favored over the other helmet conditions.

A system fielding decision will require noting the differences between ANR and CEP. Safety and performance are areas of primary importance. It is the authors' opinion that based on all aspects of hearing protection, auditory performance and safety the CEP currently provides the most effective solution for voice communication enhancement and noise reduction in rotary-wing aircraft.

References

American National Standards Institute. 1984. Method for the measurement of the real-ear attenuation of hearing protectors. 12.6 1984.

Camp, R., Mozo, B., and Patterson, J. 1975. An investigation of aircraft voice communications systems as a source of insidious long-term acoustic hazards. Proceedings of the 38th Aerospace Conference. Soesterberg Airbase, Netherlands.

Department of Defense. 1990. Physical-ear noise attenuation test. Washington, DC: MIL-STD-912. 11 December.

Department of Defense. 1991. Hearing conservation program. Washington, DC: Department of Defense Instruction 6055.12. 26 March.

Mason, Kevin T., and Mozo, Ben T. 1995. Communication earplug and active noise reduction: Hearing protection technologies for Air Warrior. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report 95-26.

Mozo, Ben T., Murphy, Barbara A., and Ribera, John E. 1995. User acceptability and comfort of the communications earplug (CEP) when used in the UH-1 helicopter. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 95-17.

Mozo, Ben T., and Murphy, Barbara A. 1996. The evaluation of sound attenuation and speech intelligibility of the communications earplug and selected active noise reduction devices when used with the HGU-56/P aviator helmet. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. In Press.

Ribera, John E., and Mozo, Ben T. 1996. A comparison of three aviation helmet systems. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Draft Report.

Shanahan, D.F. 1985. Basilar skull fracture in U.S. Army aircraft accidents. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 85-11.

Appendix A.

Weekly operational questionnaire
helmet/device appraisal

INSTRUCTIONS: You have been asked to wear a test helmet/device during your daily mission to evaluate its operational effectiveness. Please complete the following questionnaire. Most questions are self-explanatory with room for comment. Please try to be as precise as possible when making your comments. Some questions will require you to mark on a continuum between extremes. Your response should be indicative of the strength of your feelings. You may notice the environmental sounds in the aircraft that are important in allowing you to monitor overall flight safety may "sound" surprisingly "different" when using the test helmet/device. Your auditory system should "adapt" to these changes within a short period of time.

Note: Please remember that all question comparisons are between YOUR PERSONAL helmet and the test device used during this week.

Personal data:

Name:_____
Last First MI

Helmet/device # or name_____

Aircraft flown when using helmet/device_____
(please indicate EACH AC if more than one used)

# of flights with each aircraft_____
_____

Speech clarity/understanding

1. Rate the difference in **ICS** speech clarity/understanding when compared to your personal helmet.

Test helmet							
	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

2. Rate the difference in **radio** communications speech clarity/understanding when compared to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

3. Rate the difference in **VOR/ADF** signals when compared to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

4. Rate the difference in overall speech clarity/understanding when compared to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

5. Rate the difference in Air Traffic Control (ATC) speech clarity/understanding when compared to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

6. Rate the difference in speech clarity/understanding of ATC personnel based on their facility with standard English when compared to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

7. Rate the difference in speech clarity/understanding of ATC personnel based on their gender when compared to your personal helmet.

Male voice

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

Female voice

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

8. What is the usual volume control setting for **ICS** communications with **YOUR helmet** during a routine mission? (Place an x in the box below)

Off	1/4	1/3	1/2	2/3	3/4	Full on

9. What was the usual volume setting for **ICS** communication with the **test helmet/device**? (Place an x in the box below)

Off	1/4	1/3	1/2	2/3	3/4	Full on

10. What was the usual volume setting for **radio** communication with **YOUR helmet**? (Place an x in the box below)

Off	1/4	1/3	1/2	2/3	3/4	Full on

11. What was the usual volume setting for **radio** communication with the **test helmet/device**? (Place an x in the box below)

Off	1/4	1/3	1/2	2/3	3/4	Full on

Comfort

12. With respect to overall fit and comfort, compare the test device with your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

13. If you experienced discomfort during your flight when did you first notice the discomfort? Please circle the appropriate time below.

1/2 hr 1 hr 1-1/2 hrs 2 hrs 2-1/2 hrs 3 hrs 3-1/2hrs 4 hrs

14. With respect to the amount of perspiration experienced during the flight, this helmet/device was:

Acceptable _____:_____:_____:_____:_____:_____:_____Unacceptable
Highly Moderately Slightly Same Slightly Moderately Highly

15. With respect to creating hot spots during flight, this helmet/device was:

Acceptable _____:_____:_____:_____:_____:_____:_____Unacceptable
Highly Moderately Slightly Same Slightly Moderately Highly

16. With respect to earseal fit, this helmet device was:

Acceptable _____:_____:_____:_____:_____:_____:_____Unacceptable
Highly Moderately Slightly Same Slightly Moderately Highly

17. With respect to producing headaches during flight, this helmet/device was:

Acceptable _____:_____:_____:_____:_____:_____:_____Unacceptable
Highly Moderately Slightly Same Slightly Moderately Highly

18. With respect to overall fit and comfort during flight, this helmet/device was:

Acceptable _____:_____:_____:_____:_____:_____:_____Unacceptable
Highly Moderately Slightly Same Slightly Moderately Highly

19. Please elaborate on any discomfort problems you may have encountered with this helmet/ device during flight.

_____
_____
_____
_____
_____
_____

20. What changes, if any, would you make to this helmet/device to enhance its overall comfort?

_____
_____
_____
_____
_____
_____

Donning/doffing

21. With respect to donning/doffing, compare the test device to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

22. Please elaborate on any donning/doffing problems with the test/helmet device.

_____
_____
_____
_____
_____
_____

Noise reduction/attenuation

23. With respect to reducing noise levels at your ears, compare the test device to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

24. With respect to allowing you to hear navigational and caution/warning signals, compare the test device to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

25. With respect to hearing and monitoring aircraft "environmental" sounds, compare the test device to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse
	_____	_____	_____	_____	_____	_____	_____

26. With respect to reducing noise levels at your ears during weapons firing, compare the test device to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse
	_____	_____	_____	_____	_____	_____	_____

27. Rate the acceptability of the test helmet with respect to generating "extra noises".

Acceptable	Highly	Moderately	Slightly	Same	Slightly	Moderately	Highly	Unacceptable
	_____	_____	_____	_____	_____	_____	_____	

Compatibility Issues

28. Do you normally wear eye glasses when flying?.....Yes/no
If no, please go to question 29.

If yes, what type of glasses do your wear? (examples: bayonet temples, wire frames etc)

_____

If yes, how does wearing eye glasses with the test device compare to your personal helmet helmet?

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse
	_____	_____	_____	_____	_____	_____	_____

29. Rate the interface of the chemical/biological protective mask and the test device when compared to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse
	_____	_____	_____	_____	_____	_____	_____

30. Rate the interface of "ANVIS"/ other illumination aids and the test device when compared to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse
	_____	_____	_____	_____	_____	_____	_____

General issues

31. Based on your flying experience, rate the overall value of the test device when compared to your personal helmet.

Test helmet	Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse
	_____	_____	_____	_____	_____	_____	_____

32. Please elaborate on any problems you may have encountered while wearing the test helmet.

_____
_____
_____
_____
_____
_____

33. What changes would you make to the helmet/device to enhance its acceptability?

_____
_____
_____
_____
_____
_____

The USAARL staff thanks you for your participation in this study.

Appendix B.

Comprehensive operational questionnaire
helmet/device appraisal

INSTRUCTIONS: You have been asked to fly with four helmet/devices during the past several weeks to evaluate their operational effectiveness. Please complete the following questionnaire. Most of the questions are self-explanatory and leave room for comment. Some questions will require you to mark on a continuum between extremes. Your responses should be indicative of the strength of your feelings. Please try to be as objective as possible when recalling the strengths/weaknesses of each helmet in the performance of rank order comparisons.

Personal data:

Name:_____
Last First MI

Rank:_____

Birth Date:_____/_____/_____ **Age:**_____**years SSN:**_____-____-_____ **Sex:M**___**F**___
Day Month Year

Unit:_____
Location/Installation:_____

Type of aviation helmet worn before study participation:_____

Flight status:_____**Aviator** _____**Crewmember**

Experience as a helicopter aviator/crewmember: ___**years Number of flight hours**____

1. Do you have a hearing loss?.....Yes/no

2. Do you have a hearing loss flight waiver?.....Yes/no

Speech clarity/understanding

3. Please rank order the helmet/devices relative to clarity of in-flight communications from 1 (clearest) through 4 (least clear).

____HGU-56/P ____Bose ANR
____HGU-CEP ____Gentex ANR

4. Please rank order the helmet/devices relative to **ICS** volume control changes from 1 (greatest lowering of ICS volume) through 4 (least lowering).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

5. Please rank order the helmet/devices relative to speech clarity/understanding of **ICS** communication from 1 (clearest) to 4 (least clear).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

6. Please rank order the helmet/devices relative to **radio** volume control changes from 1 (greatest lowering of radio volume) through 4 (least lowering).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

7. Please rank order the helmet/devices relative to speech clarity/understanding of **radio** communication from 1 (clearest) to 4 (least clear).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

8. Please rank order the helmet/devices relative to Air Traffic Controller (ATC) transmission(s) speech clarity/understanding based on their gender (1 best, 4 worst).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

9. Please rank order the helmet/devices relative to ATC transmission(s) speech clarity/ understanding based on their facility with standard English (1 best, 4 worst).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

10. Please elaborate on other speech clarity/understanding concerns you may have encountered when wearing the trial helmets.

_____
_____
_____
_____
_____
_____

Comfort

11. Did you wear personal hearing protection (PHP) with any of the helmet/devices other than the HGU-CEP?.....Yes/no

If yes, which helmets were utilized with PHP?
____HGU-56/P
____Bose ANR
____Gentex ANR

If discomfort was experienced during flight, indicate the helmet and time into the mission that discomfort was first noticed. Please circle the appropriate time below and indicate the helmet/devices as appropriate.

1/2 hr 1 hr 1-1/2 hrs 2 hrs 2-1/2 hrs 3 hrs 3-1/2 hrs 4 hrs

HGU-56/P
Bose ANR
Gentex ANR

12. Please rank order the helmet/devices with respect to earseal fit from 1 (most comfortable) through 4 (least comfortable).
____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

13. Please rank order the helmet/devices with respect to limiting perspiration, hot spots and headaches from 1 (least # of occurrences) through 4 (greatest # of occurrences).
____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

Please specify any type of discomfort that occurred with each helmet:
HGU-56/P_____
HGU-CEP_____
Bose ANR_____
Gentex ANR_____

14. Please rank order the helmet/devices in terms of overall comfort from 1 (most comfortable) through 4 (least comfortable).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

15. Please elaborate on any additional comfort issues you may have encountered while wearing the helmet/ devices.

_____
_____
_____
_____
_____
_____

Donning/doffing

16. Please rank order the helmet/devices regarding donning/doffing difficulty from 1 (easiest) through 4 (most difficult).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

17. Please elaborate on any additional donning/doffing issues you may have encountered while wearing the helmet/devices.

_____
_____
_____
_____
_____
_____

Noise reduction/attenuation

18. Please rank order the helmet/devices in reducing noise levels at your ears from 1 (most reduction) through 4 (least reduction).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

19. Please rank order the helmet/devices with respect to allowing you to hear navigational and warning signals from 1 (easiest to hear) through 4 (most difficult to hear).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

20. Please rank order the helmet/devices with respect to communication, navigation and warning signal clarity during aircraft weapons firing from 1 (easiest to hear) through 4 (most difficult to hear.

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

21. Please rank order the helmet/devices with respect to your ability to hear and monitor aircraft "environmental" sounds from 1 (easiest to hear) through 4 (most difficult to hear).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

22. Please rank order the test devices with respect to the helmet generating any "extra noises" from 1 (least amount of "extra" noises) through 4 (greatest amount).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

23. Please elaborate on any other noise reduction issues you may have encountered while wearing the helmet/devices.

_____
_____
_____
_____
_____
_____

Compatibility issues

24. Please rank order the helmet/devices with respect to compatibility when eyeglasses were used in flight from 1 (most compatible) through 4 (least compatible). (*Please skip to the next question if eye glasses were not worn)

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

25. Please rank order the devices with respect to compatibility during flight when a chemical/biological protective mask was used from 1 (greatest degree of compatibility) through 4 (least compatibility).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

26. Please rank order the devices with respect to helmet/ANVIS or other illumination aid compatibility from 1 (greatest degree of compatibility) through 4 (least degree of compatibility).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

General Issues

27. Please elaborate on any additional problems you may have encountered while wearing the the helmet/devices.

_____
_____
_____
_____
_____

28. Please rank order the helmet/devices with respect to degree of operational benefit from 1 (greatest) through 4 (least).

____HGU-56/P
____HGU-CEP
____Bose ANR
____Gentex ANR

29. Please comment about additional positive aspects of any or all of the helmet/devices.

_____
_____
_____
_____
_____
_____
_____
_____

30. Which helmet/device would you prefer as a "take home" item for personal use? Please circle your choice.

HGU-56/P
HGU-CEP
Bose ANR
Gentex ANR

The USAARL staff thanks you for your participation in this study.

Appendix C.

Manufacturer's list.

Bose Corporation
The Mountain
Framingham, MA 01701-9168

Gentex Corporation
P.O. Box 315
Carbondale, PA 18407

Grumman Aerospace Corporation
South Oyster Bay Road
Bethpage, NY 11714

DEPARTMENT OF THE ARMY
U.S. ARMY AEROMEDICAL RESEARCH LABORATORY
POST OFFICE BOX 620577
FORT RUCKER ALABAMA 36362-0577

REPLY TO
ATTENTION OF

March 18, 2003

Office of the Commander

Defense Technical Information Center
DTIC-OCQ, Attn: Larry Downing
STE 0930
8725 John J. Kingman Road
Fort Belvoir, VA 22060-6218

Dear Mr. Downing:

This letter serves as an official request to change the distribution statement from "U.S. Government Only" to "Approved for Public Release" for the following reports:

(1) ADB222028, Assessment of Sound Attenuation and Speech Intelligibility of Selected Active Noise Reduction Devices and the Communications Earplug When Used with the HGU-56/P Aviator Helmet

(2) ADB220453, Operational Test to Evaluate the Effectiveness of the Communication Earplug and Active Noise Reduction Devices When Used with the HGU-56/P Aviator Helmet

Point of contact for this matter is Ms. Diana L. Hemphill, telephone DSN 558-6907, (334) 255-6907 or by e-mail at diana.hemphill@se.amedd.army.mil.

Sincerely,

Brian S. Campbell
Colonel, Medical Corps
Commander, U.S. Army Aeromedical
Research Laboratory

Copies furnished:
Dr. William Ahroon
Mr. Ben Mozo